Energy+Environmental Economics

Title 24 Rooftop PV Cost-Effectiveness Analysis

California Energy Commission

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Agenda

- **Executive Summary (9am to 9:30am)**
- **Question and Answer (9:30am to 10am)**
- **Analysis Overview (10am to 10:45am)**
  - PV Capital Costs
  - PV Financial Analysis
  - Approach 1: Average Consumer Savings Analysis
  - Approach 2: Market-Segmented Analysis
- **Question and Answer (10:45am to 11:30am)**

About E3

- E3 is an electricity consulting firm founded in 1989 in San Francisco
- Clients span local, state and federal government, small and large public and investor-owned electric utilities, and energy technology companies
- Lead consultant on developing TDV for the CEC, and for evaluating economics of California Solar Initiative
- Approximately 30 staff in energy economics, distributed resources, policy implementation, and resource planning

EXECUTIVE SUMMARY

Purpose of Study

- **Determine whether rooftop PV will be cost-effective if included in Title 24 Building Energy Efficiency Standards**
  - Analysis required by Senate Bill 1 (Murray, Chapter 132, Statutes of 2006)
- **First public CEC analysis in response to statute**
- **This study is narrowly focused on cost-effectiveness, and does not address other issues associated with mandating PV in new construction**

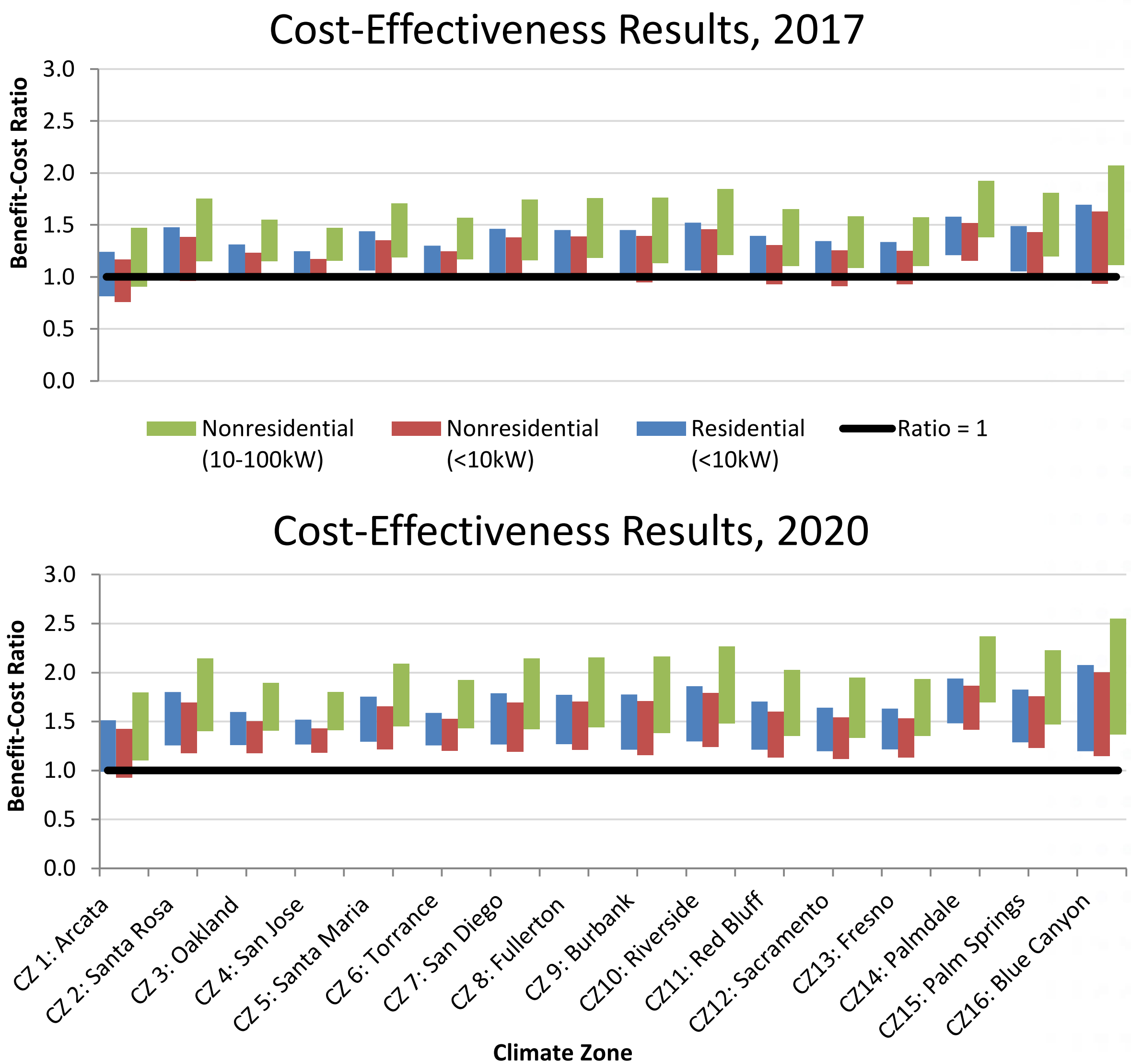
Cost-Effectiveness Framework

- **Lifecycle benefits calculated using two parallel approaches**
  1. Average Consumer Analysis
     - Same method as used for Title 24 cost-effectiveness
  2. Market Segmented Analysis
     - Estimate of the actual cost-effectiveness of the solar PV to building owner
- **Lifecycle PV costs calculated using financial *pro forma* model and PV capital cost forecast**

Results Summary

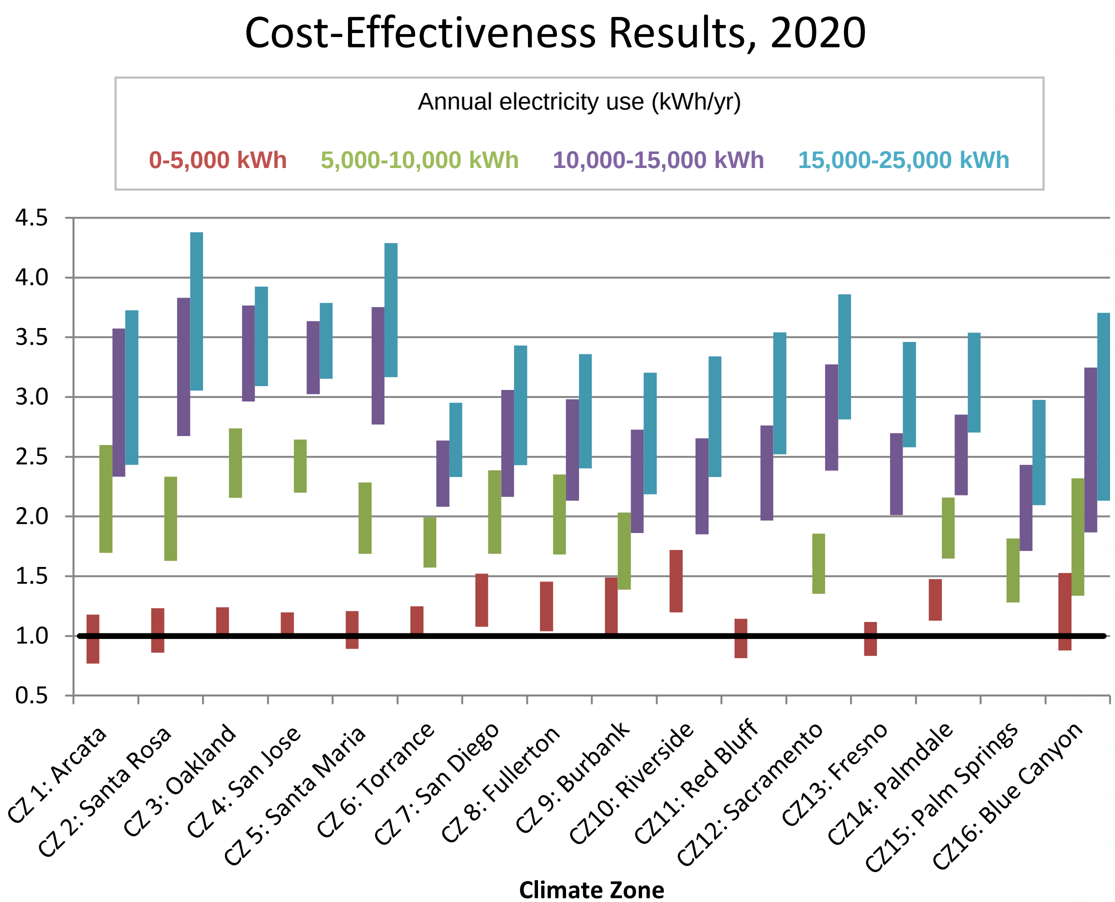
- **Results indicate that…**
  1. Solar PV on new buildings is forecast to be cost-effective for the next cycle of building codes
  2. Solar PV is forecast to be cost-effective for many residential and commercial market segments
- **Requirements for these findings**
  - Continuation of NEM and current utility rate designs, particularly the inclining block residential rate
  - Continued decline in PV prices beyond parity with retail rates

Average Consumer Savings Results



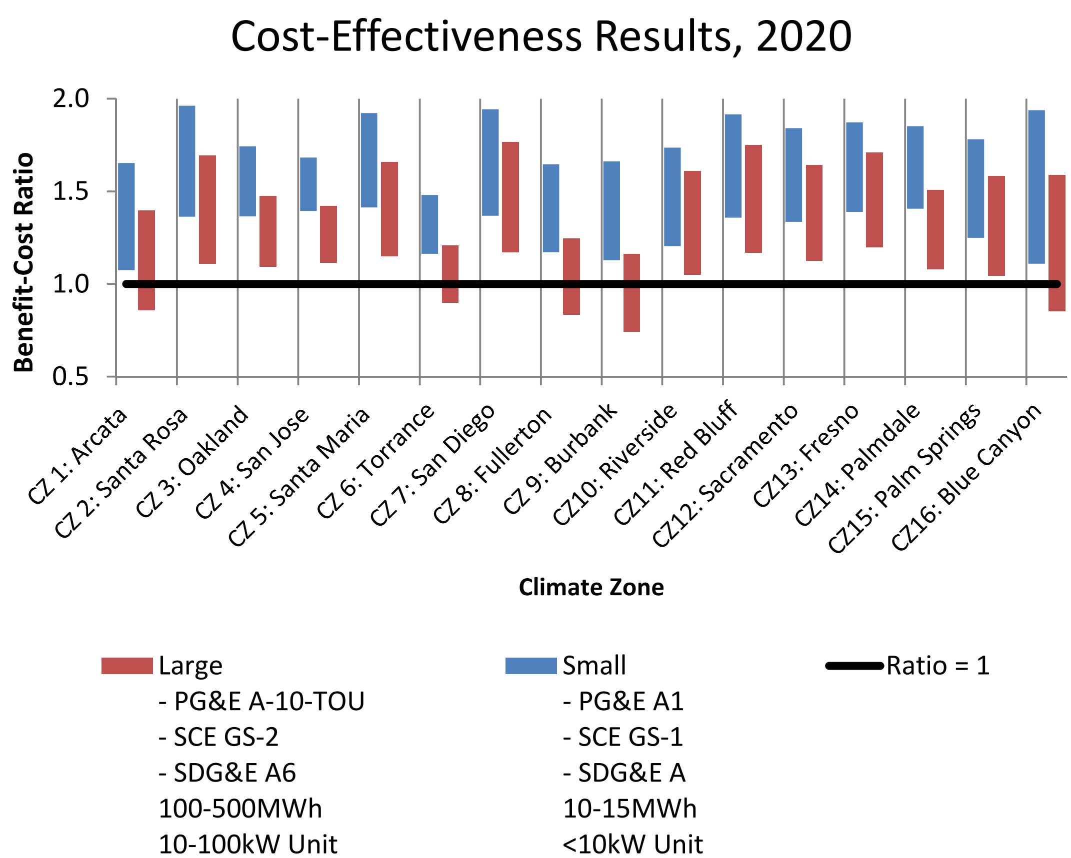
- In 2017, PV is forecast to be cost effective under a low cost scenario across all sectors and climate zones
- In a 2017 high cost scenario, PV is marginally cost effective, depending on climate zone, consumer type and PV system size
- By 2020, PV is cost effective in most climate zones under both a low and high cost scenario, due to predicted declines in PV prices

Market-Segmented Results: Residential



- Residential consumers segmented by total annual usage
- Due to inverted block residential rate structures, usage has a significant impact on PV cost-effectiveness
- In 2020, PV is forecast to be cost-effective for all residential consumers with annual usage greater than 5,000 kWh

Market-Segmented Results: Commercial



- **Commercial consumers segmented by size**
  - Different rates used for small and large consumers
  - Different PV system sizes assigned to each sector
- **Cost-effectiveness results are heavily impacted by utility rate structures**
  - Small commercial customers' rate structures result in larger bill savings from PV
  - Large commercial customers' rate structures result in less cost-effective PV, especially in SCE territory

Incorporating PV into Title 24

- **Challenges beyond cost-effectiveness exist that this study does not address**
- **For example,**
  - Some sites are not good candidates for solar, and existing rules to allow flexible compliance through ACM may need to be adjusted
  - Allowing solar PV to displace energy efficiency measures in Title 24 may undermine drive to more efficient buildings

Question & Answer

ANALYSIS OVERVIEW

KEY METHODS, FIGURES AND FINDINGS IN THE REPORT

Analysis Approach

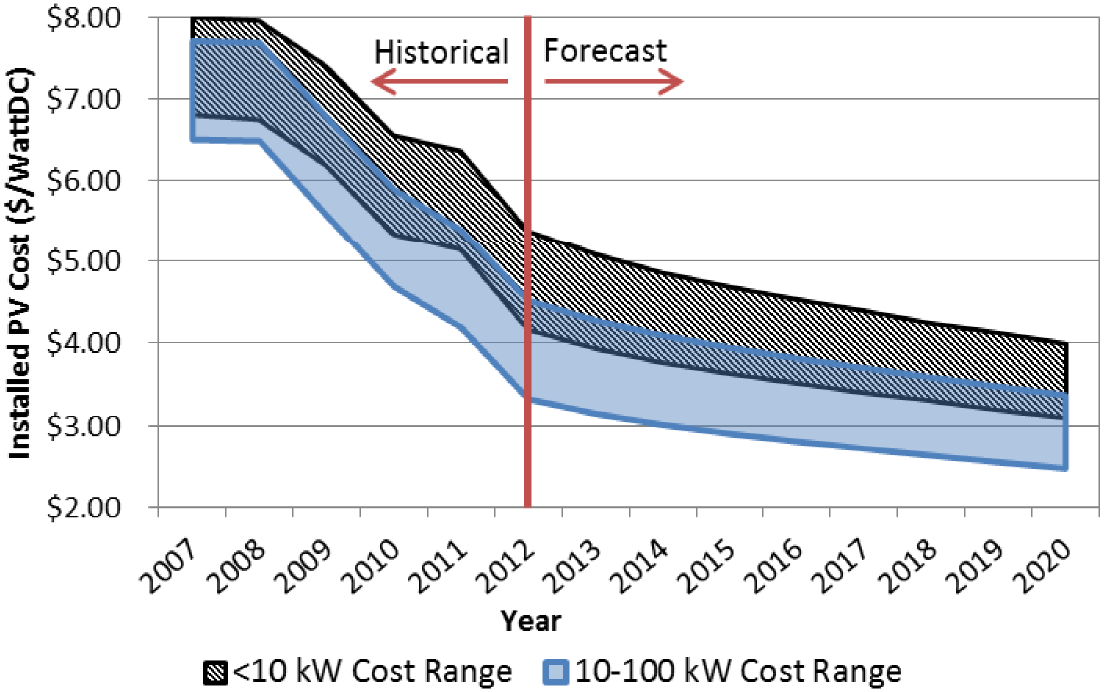
Costs	Benefits
PV Levelized Cost of Electricity (LCOE) Parameters include: • Upfront capital cost • Inverter, insurance, O&M costs • Capacity factor & degradation • Financing terms • Tax considerations • Useful system life	**Approach 1: TDVs** Using 2013 TDV base values, standard for Title 24 cost-effectiveness analysis
	Approach 2: Utility Bill Savings

PV Capital Costs

- **Analysis uses high and low PV cost estimates to compare a range of possible costs**
  - High estimate: Assume current installed PV costs are the same as current costs from CSI PowerClerk database
    - Because most projects in CSI database are retrofits, median values from database were used for high estimate
  - Low estimate: PV installed as part of new construction
    - “Tracking the Sun V” report estimates a $1.20/Watt cost difference between retrofit and new construction, based on reported costs from CSI database and NSHP program
- **Two size ranges included in analysis**
  - <10 kW for residential and small commercial consumers
  - 10-100 kW for large commercial consumers

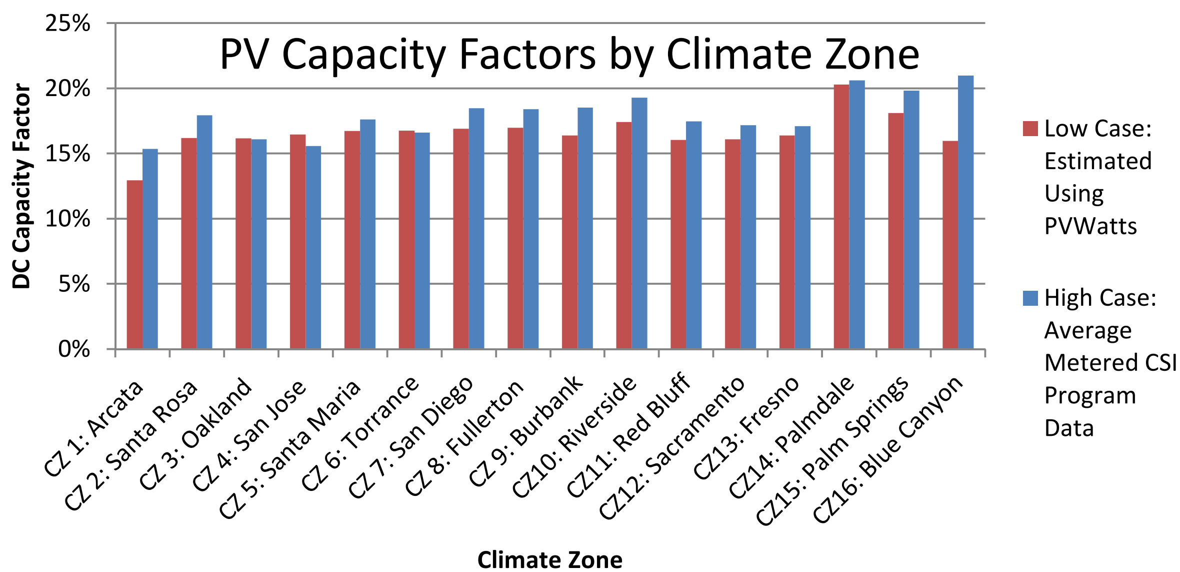
PV Capital Cost Forecast

- Future PV costs are forecast using an 80% progress ratio: when *global* capacity doubles, PV cost drops 20%
- Progress ratio applied to 2012 CSI data to generate costs for 2013 through 2020



PV System Performance

- **PV capacity factors assigned to each of California's 16 climate zones**
- **High and low capacity factors used to create range of possible performance in each zone**
  - Capacity factors simulated in PVWatts, an NREL simulation tool, used as low case
  - In most climate zones, capacity factors derived from real metered generation data from CSI load impact studies are higher than simulated capacity factors; used as high case



PV Cost Scenarios

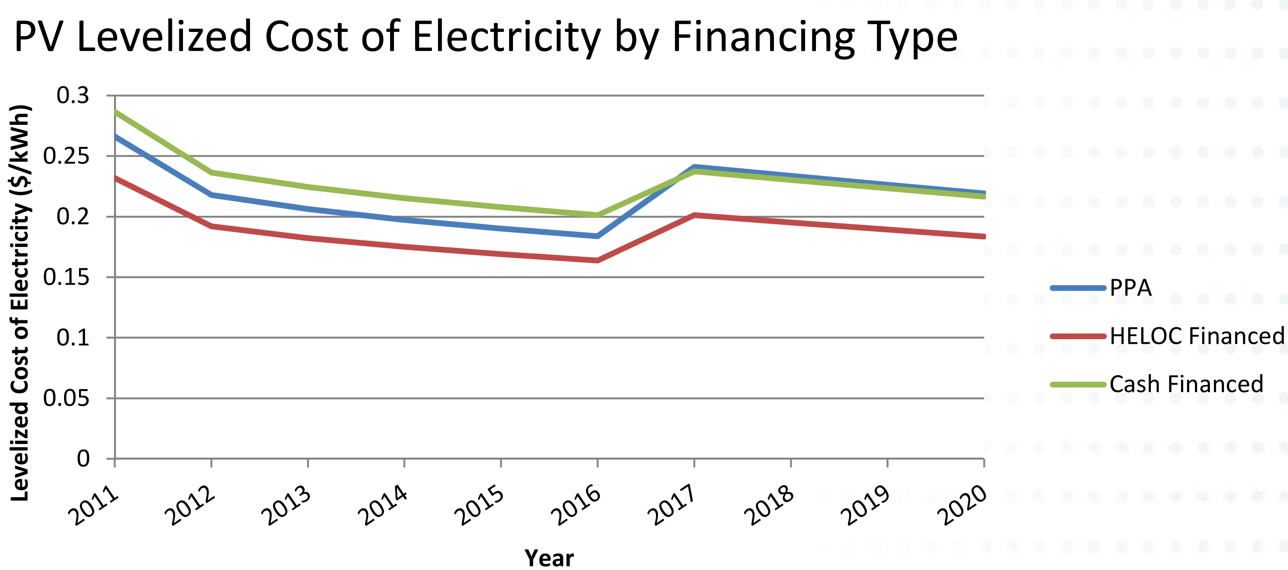
- **Ranges of PV capital costs and capacity factors combined to generate two scenarios for analysis**
- **Scenario 1: High Cost Solar**
  - High capital cost
  - Low capacity factor
- **Scenario 2: Low Cost Solar**
  - Low capital cost
  - High capacity factor
- **High and low benchmarks give expected range of costs**

PV Financing

- **E3 compared 3 common financing options available to rooftop PV customers:**
  - PPA (private purchase agreement): system is owned by a third-party installer who sells electricity to customer
  - HELOC (home equity line of credit): customer owns system and finances the full cost with debt, borrowed against home equity at a low interest rate with tax deductible interest
  - Cash: customer owns system and finances the full cost with cash
- **Options compared on basis of levelized cost of electricity (LCOE), calculated using financial *pro forma* model**
- **Analysis assumes 20 year PPA term, 25 year useful module life, 10 year inverter life**
  - Based on current industry standards for PPA terms and PV module & inverter warranties

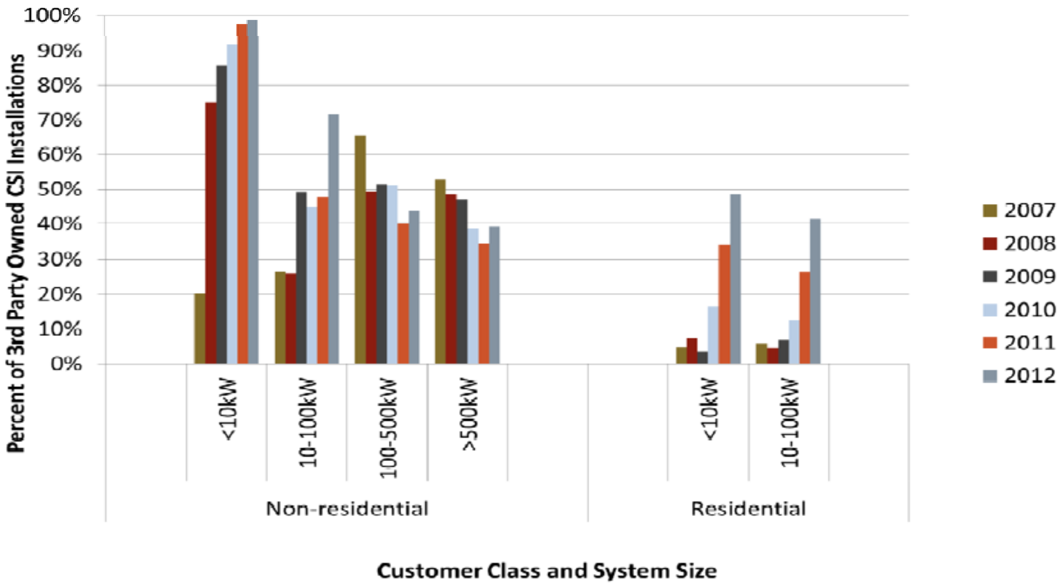
PV Financing Comparison

- **Analysis shows that PPA financing is more expensive than HELOC financing**
  - Cost of capital is lower with a HELOC
  - Equity return is taxable under PPA financing
  - Those increased costs outweigh PPA savings from MACRS depreciation
  - Analysis does not include Bonus Depreciation, which is set to expire at the end of 2013 (part of the recovery act, not permanent policy)



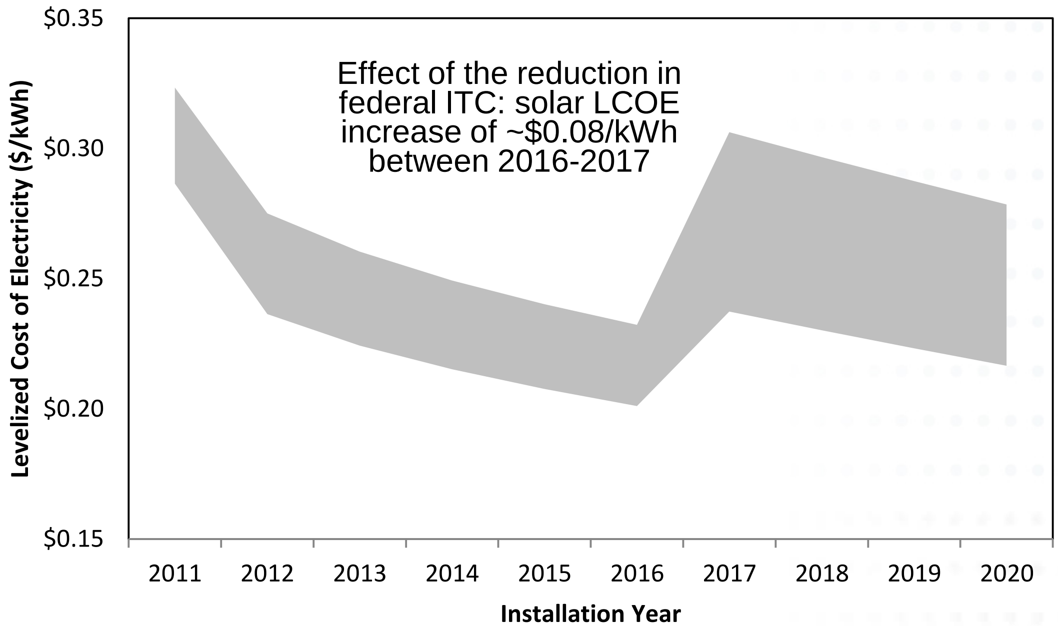
Prevalence of PPA Financing

- **Despite relative expense, PPA financing is becoming increasingly common for residential systems**
  - Benefits of reduced maintenance, avoids borrowing
- **PPAs account for almost all non-residential rooftop PV installations**
- **We expect trend to continue and have performed all analysis assuming PPA financing**
- **PPA leases are priced to generate a 7.7% after-tax return on capital, reflecting the underlying assumption that PPA pricing in California is highly competitive**



Investment Tax Credit

- ITC applied to all installations
- 30% tax credit until 2017, when it drops to 10%
  - Consistent with current federal policy
- Financial analysis assumes than all benefits of ITC can be fully monetized

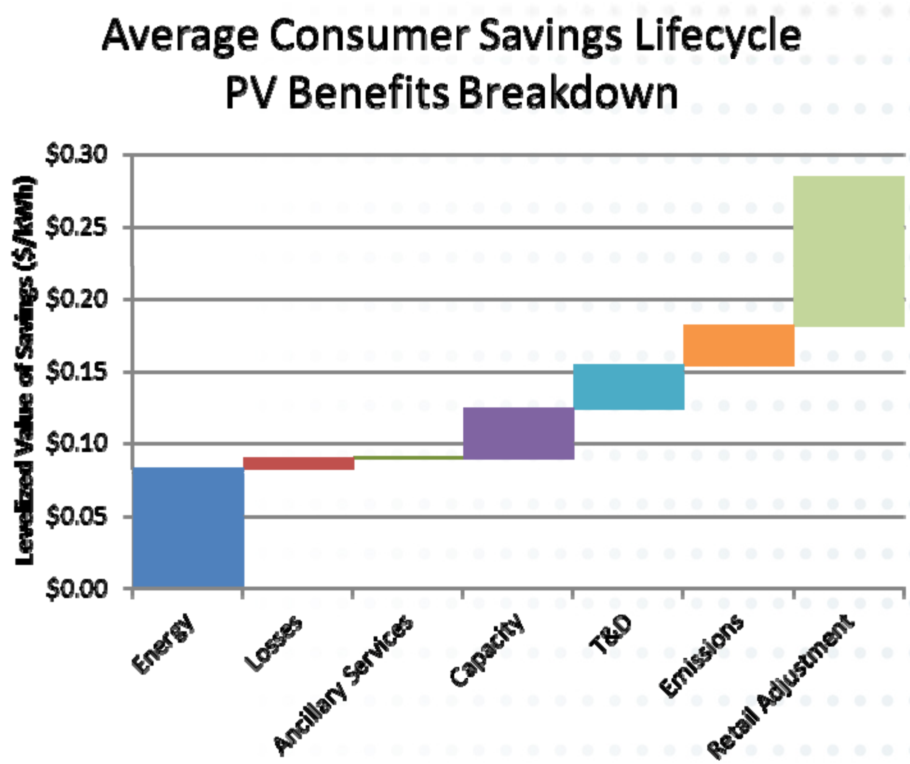


Analysis Approaches

- **Benefits are calculated using two complementary approaches**
  - Average Consumer approach: estimate of cost savings to the average consumer based on statewide average retail electricity rates
  - Market Segmented approach: estimate of cost savings to specific consumer segments based on avoided utility electricity bills
- **In each approach, benefits are levelized over 25 year period and compared to PV LCOE**

Average Consumer Savings Analysis

- Average consumer savings calculated with Time Dependent Valuation (TDV) analysis
- Analysis uses TDV "base" values developed as part of the CEC's update to the 2013 Building Energy Efficiency Standards
- TDV components include hourly avoided energy, capacity, transmission & distribution, and greenhouse gas emissions costs
- A retail rate adder is added to the avoided costs to equate TDV values to statewide average retail rates



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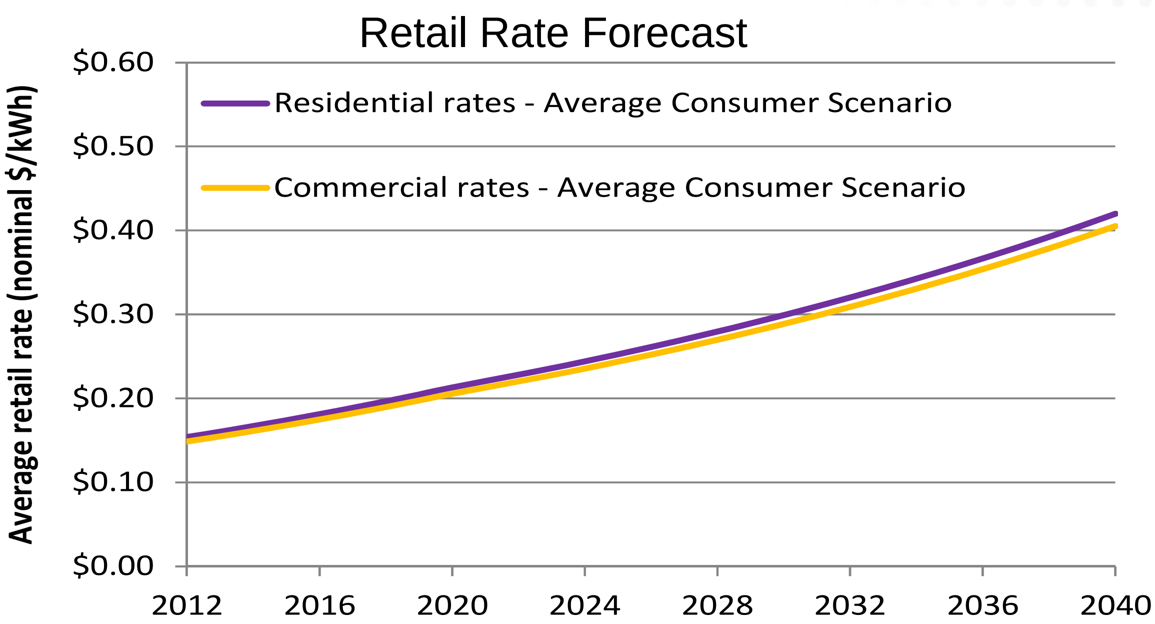
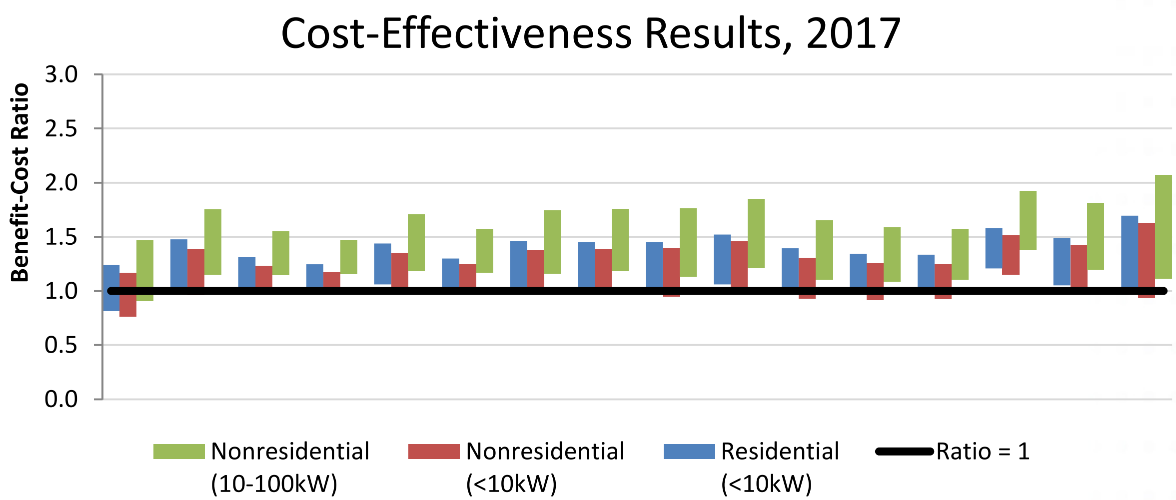
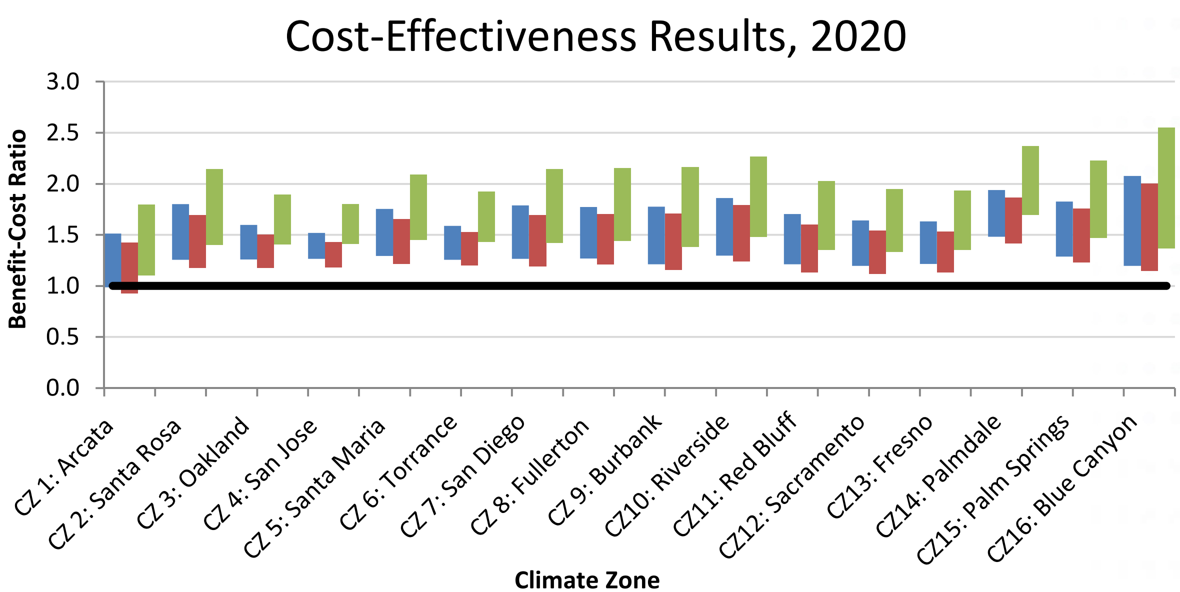
Average Retail Rate Forecast

- **Retail rate adders for residential and commercial consumers are developed based on retail rate forecast**
- **Analysis uses forecast adopted in the 2013 Title 24 building standards proceeding**
  - 2.11% real annual increase through 2020, 1.42% real annual increase beyond 2020
  - Originally created for CARB 33% RPS evaluation



Average Consumer Savings Results





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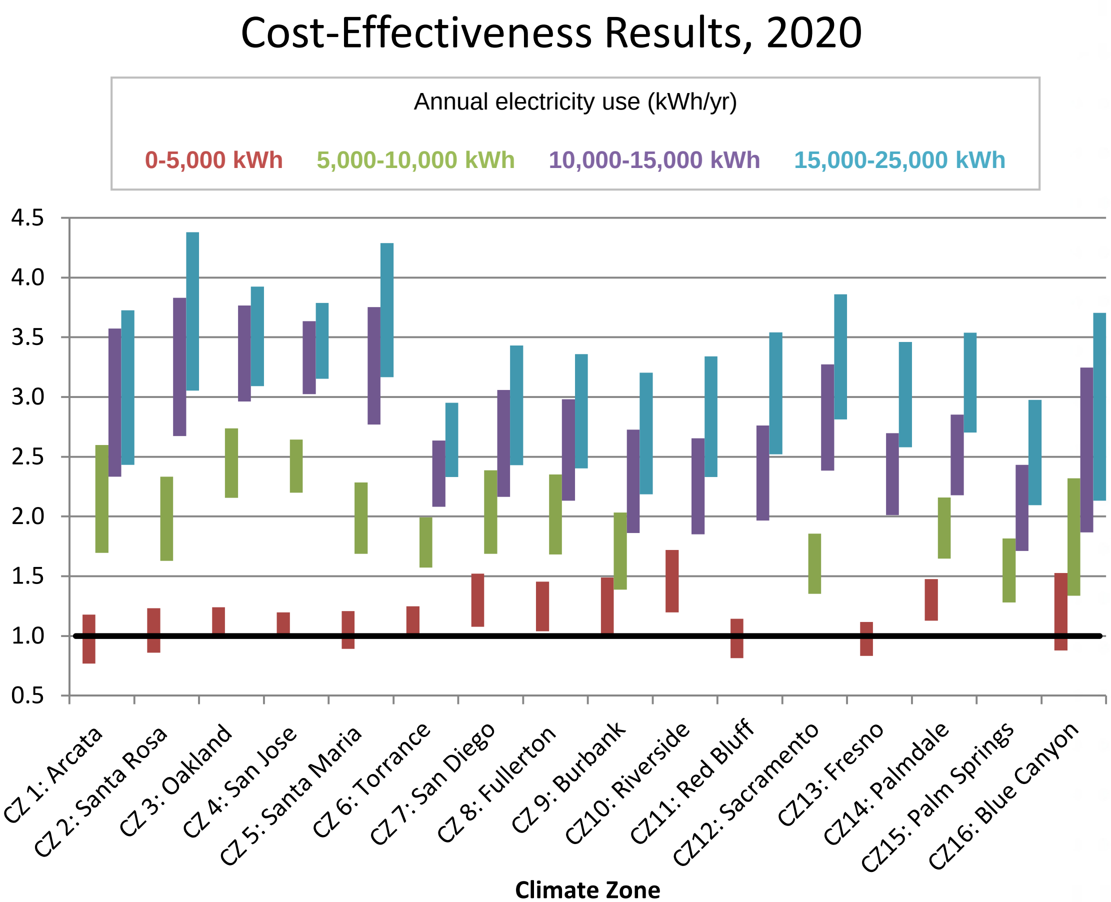
Market-Segmented Analysis

- Market-segmented benefits are calculated based on avoided electricity bills
- Customers are segmented by sector (residential and commercial) and consumption level
- Appropriate residential, small commercial, and large commercial rates are assigned to each climate zone based on alignment with IOU territory

Bill Savings Calculation

- Bill savings are calculated from 2 hourly load shapes: customer gross load in absence of PV, and customer net load after PV is installed
- Bills calculated with E3 in-house tool developed for the CPUC NEM analysis
- Savings are escalated for years after 2011 using retail rate escalation forecast
- Bill calculations assume participation in Net Energy Metering (NEM)

Market-Segmented Results: Residential



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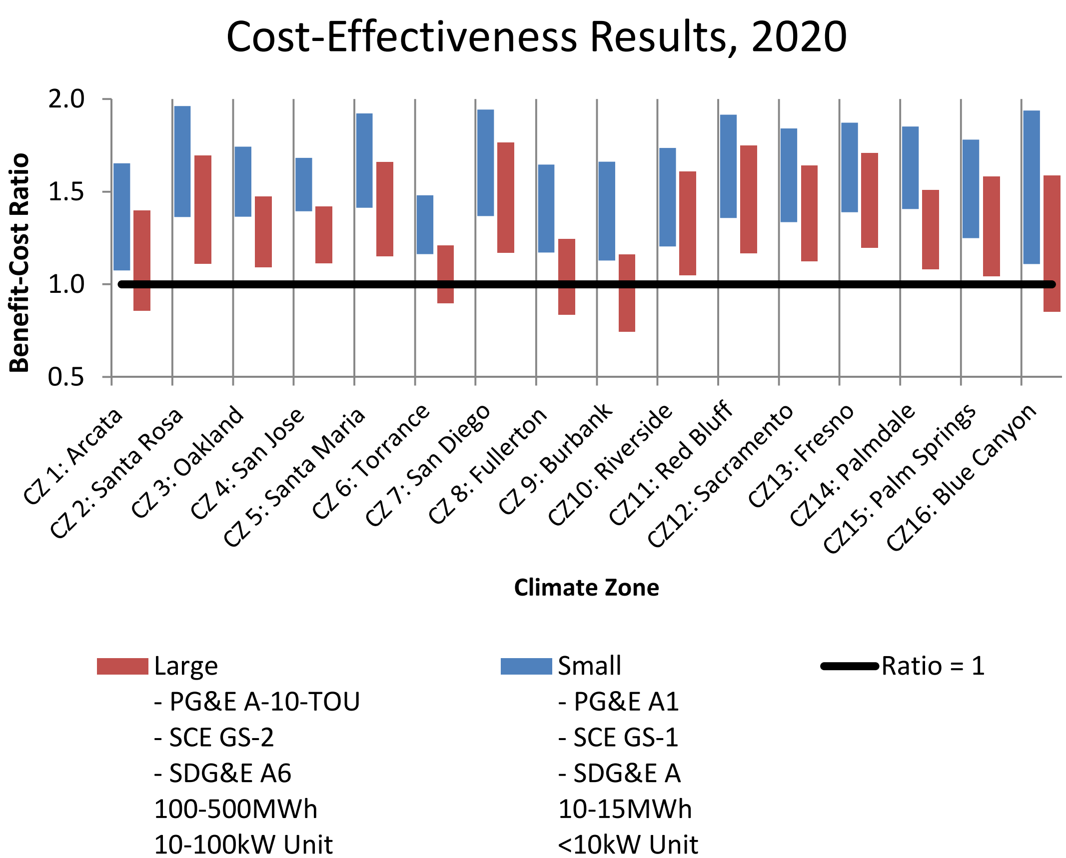

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Understanding Results

- **Results indicate that solar PV on new buildings will likely be cost-effective for the next cycle of building codes**
- **Solar PV will be cost-effective for many residential and commercial market segments**
- **Requirements for these findings**
  - Continuation of NEM and current utility rate designs, particularly the inclining block residential rate
  - Continued decline in PV prices is required beyond parity in retail rates
- **Incorporating PV into Title 24**
  - Challenges exist beyond cost-effectiveness exist that this study does not address
  - Some sites are not good candidates for solar, and existing rules to allow flexible compliance through ACM may need to be adjusted
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Question and Answer

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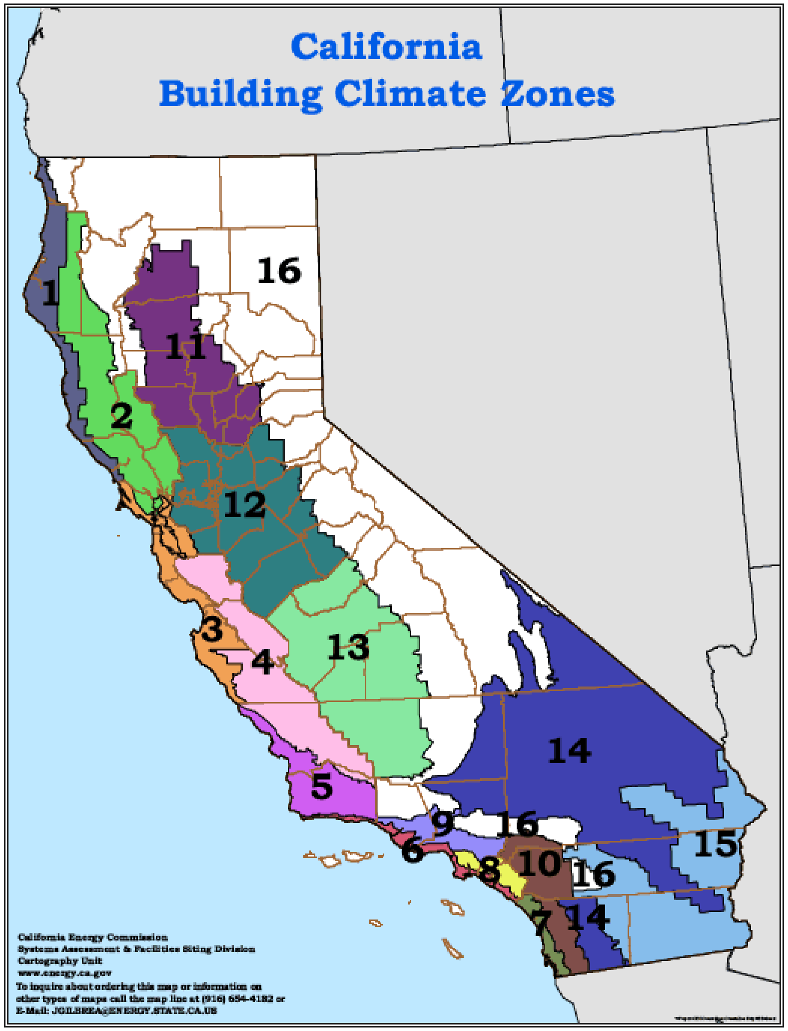
Appendix

Climate Zone Assignments



CZ	Utility	CZ	Utility
1	PG&E	9	SCE
2	PG&E	10	SCE
3	PG&E	11	PG&E
4	PG&E	12	PG&E
5	PG&E	13	PG&E
6	SCE	14	SCE
7	SDG&E	15	SCE
8	SCE	16	SCE